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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 90.

B. T. GALLOWAY, *Chief of Bureau.*

MISCELLANEOUS PAPERS.

I. THE STORAGE AND GERMINATION OF WILD RICE SEED.
By J. W. T. DUVEL, *Assistant.*

II. THE CROWN-GALL AND HAIRY-ROOT DISEASES OF THE APPLE TREE.
By GEORGE G. HEDGCOCK, *Assistant.*

III. PEPPERMINT.
By ALICE HENKEL, *Assistant.*

IV. THE POISONOUS ACTION OF JOHNSON GRASS.
By A. C. CRAWFORD, *Pharmacologist.*

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BUREAU OF PLANT INDUSTRY.

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Pathologist and Physiologist, and Chief of Bureau.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

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[a] The four papers constituting this Bulletin were issued in separate form on September 7, November 17, December 28, 1905, and January 17, 1906, respectively.

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MISCELLANEOUS PAPERS.

B. P. I.—178.

I.—THE STORAGE AND GERMINATION OF WILD RICE SEED.[a]

By J. W. T. Duvel, *Assistant in the Seed Laboratory.*

INTRODUCTION.

The seed of wild rice, sometimes called Indian rice or water oats (*Zizania aquatica* L.), has always been a very valuable food among the Indians, especially those of the upper Mississippi Valley. Of recent years wild rice has found a place on the menu cards of some of our best American hotels. The rich and highly nutritious grains, together with the slightly smoky flavor it has when properly prepared, make it an extremely palatable article of diet. If it were not for the difficulties of harvesting the seed and preparing the finished product for market it is probable that wild rice would find a place in many American homes.

At present, however, the greatest interest in wild rice is created by the value of the seed as a food for wild waterfowl, particularly wild ducks. As a result of this interest the propagation of wild rice from seed has become a question of considerable importance, especially to the members of the gunning clubs throughout the United States and Canada.

DISTRIBUTION.

The distribution of wild rice is now reported from New Brunswick and Assiniboia south to Florida, Louisiana, and Texas. There are, however, comparatively few localities in which it grows abundantly.

[a] Wild rice is considered one of the most important foods for wild ducks and other waterfowl, and a large number of inquiries have been received from members of gunning clubs throughout the United States asking where good, germinable seed can be secured. It is quite generally recognized that wild rice seed loses its vitality if allowed to become dry, and better methods of storing the seed during the winter have long since been demanded.

The results of investigations begun two years ago show that wild rice seed can be handled without any deterioration in vitality if it is harvested and stored according to methods outlined in the present paper.

J. W. T. Duvel, *Acting Botanist in Charge of Seed Laboratory.*

Seed Laboratory,
Washington, D. C., July 20, 1905.

Good reasons exist for assuming that this area can be extended to include all fresh-water lakes, as well as swamps and river bogs, where the water does not become stagnant, throughout the whole of North America south of latitude 55° north. Wild rice also grows luxuriantly along the lower parts of many of the rivers of the Atlantic Coast States, the waters of which are affected by the action of the tide to a considerable degree, and consequently contain an appreciable quantity of salt. It has been shown[a] that the maximum degree of concentration of salt water in which wild rice plants can grow successfully is equivalent to a 0.03 normal solution of sodium chlorid. This concentration corresponds to 0.1755 per cent by weight of sodium chlorid, which is sufficient to give a slight salty taste to the water.

HABITAT.

While it is well recognized that the habitat of the wild rice plant is in shallow fresh water, it is now known that it will grow luxuriantly in water containing little less than two-tenths of 1 per cent of sodium chlorid. Occasional plants have been found growing in water which contained, for short periods at least, nearly double that amount of salt. These facts indicate the possibility of a much wider range of conditions to which this plant may be subjected without hindering its development. It is not beyond the range of possibility—indeed, it is quite probable—that by careful selection plants may be obtained which will thrive on soil that is comparatively dry, at least in places in which the water can be drawn off gradually during the latter part of the growing season.

In September, 1904, Mr. G. C. Worthen, of the Bureau of Plant Industry, collected a cluster of wild rice plants which were growing on the Potomac Flats, near Washington, D. C., in soil which was sufficiently dry to permit the use of a 2-horse mowing machine for cutting down the rank growth of vegetation. This was newly made land, and in all probability the seed giving rise to this cluster of plants was pumped in with the dirt from the Potomac River the year previous.

This amphibious type once established, it will undoubtedly carry with it a strain of seed which can withstand considerable drying without any marked injury to its vitality. Such being true, the methods and difficulties of propagation from seed would be greatly simplified.

Simultaneous with establishing an amphibious type should come the selection of seed plants which are capable of retaining their seed until the larger part of it has reached maturity. These two steps once made, the future of wild rice as a cereal will be assured.

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[a] The Salt Water Limits of Wild Rice. Bulletin No. 72, Part II, Bureau of Plant Industry, United States Department of Agriculture, 1905.

GERMINATION OF THE SEED.

The greatest difficulty to be overcome in extending the area for growing wild rice is the poor germination of the commercial seed. Inasmuch as wild rice constitutes one of the most important foods of wild ducks and other wild waterfowl, many individuals and most of the gunning clubs east of the Rocky Mountains have been asking the question, How can we propagate wild rice from seed in order to establish better feeding and fattening grounds for our game birds?

The many failures in the propagation of wild rice from seed have been due to the use of seed that had become dry before sowing, or to the fact that the seed when sown fresh in the autumn had been eaten by ducks or other animals or was carried away by heavy floods before germination took place.

It is now very generally known that the seed of wild rice, if once allowed to become dry, will not germinate, save possibly an occasional grain. In its natural habitat the seed, as soon as mature, falls into the water and sinks into the mud beneath, where it remains during the winter months, germinating the following spring if conditions are favorable.

Heretofore the plan generally followed, and the one usually recommended by those who have given some attention to the propagation of wild rice, was practically that of natural seeding; that is, to gather the seed in the autumn, as soon as thoroughly mature, and, while still fresh, to sow it in 1 to 3 feet of water.

FALL SEEDING VERSUS SPRING SEEDING.

It must be remembered that the bulk of the seed remains dormant during the winter, germinating first the spring after maturing; consequently, with but few exceptions, fall seeding is unsatisfactory and unreliable. Fall seeding is likely to prove a failure for three reasons: (1) Wild ducks and other animals of various kinds eat or destroy the seed in considerable quantity before it has had time to germinate the following spring; (2) much of the seed is frequently covered so deeply with mud that washes in from the shore during the winter that the young plants die of suffocation and starvation before they reach the surface; (3) in some cases a large quantity of the seed is carried away from the place where sown by the high waters and floating ice prevalent during the latter part of the winter and early spring.

In exceptional cases these difficulties can be overcome; under which circumstances autumn sowing may be preferable to spring sowing. In the majority of cases, however, much better results will be obtained if the seed is properly stored and sown in the early spring, as soon as the danger of heavy floods is passed and the water level approaches normal.

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In sowing the seed considerable care must be exercised in selecting a suitable place, securing the proper depth of water, etc. Good results can be expected if the seed is sown in from 1 to 3 feet of water which is not too stagnant or too swiftly moving, with a thick layer of soft mud underneath.[a] It is useless to sow wild rice seed on a gravelly bottom or in water where the seed will be constantly disturbed by strong currents.

Previous to this time, save in a few reported cases, the seed which was allowed to dry during the winter and was sown the following spring gave only negative results. It is now definitely known that wild rice, if properly handled, can be stored during the winter without impairing the quality of germination to any appreciable degree, and that it can be sown the following spring or summer with good success.

DIRECTIONS FOR STORING THE SEED.

The vitality of wild rice seed is preserved almost perfectly if kept wet in cold storage—Nature's method of preservation. This method of storage implies that the seed has been properly harvested and cared for up to the time of storage. The seed should be gathered as soon as mature, put loosely into sacks (preferably burlap), and sent at once to the cold-storage rooms. If the wild rice fields are some distance from the cold-storage plant the sacks of seed should be sent by express, and unless prompt delivery can be guaranteed it is not advisable to send by freight even for comparatively short distances. It is very important that the period between the time of harvesting and the time when the seed is put into cold storage be as short as possible. If this time is prolonged to such an extent as to admit of much fermentation or to allow the seed near the outside of the bags to become dry during transit, its vitality will be greatly lowered.

It is not practicable to give any definite length of time which may elapse between harvesting and storing, inasmuch as the temperature, humidity, and general weather conditions, as well as the methods of handling the seed, must be taken into consideration. Let it suffice to say, however, that the vitality of the seed will be the stronger the sooner it is put into cold storage after harvesting.

As soon as the seed is received at the cold-storage plant, while it is still fresh and before fermentation has taken place, it should be put into buckets, open barrels, or vats, covered with fresh water, and placed at once in cold storage. If there is present a considerable quantity of light immature seed or straw, broken sticks, etc., it will be profitable to separate this from the good seed by floating in water

[a] Wild Rice: Its Uses and Propagation. Bulletin No. 50, Bureau of Plant Industry, United States Department of Agriculture, 1903.

preparatory to storing. The storage room should be maintained at a temperature just above freezing—what the storage men usually designate as the "chill room."

When taken from cold storage in the spring the seed must not be allowed to dry out before planting, as a few days' drying will destroy every embryo.

Seed which was stored under the foregoing conditions from October 19, 1903, to November 15, 1904, 393 days, germinated from 80 to 88 per cent. Another lot of seed, which was stored on October 6, 1904, and tested for vitality on April 17, 1905, germinated 79.8 per cent.

Plate I shows the luxuriant growth made by the seed which was kept wet and stored at a temperature of 32° to 34° F. for 393 days.

DETAILED CONDITIONS AND RESULTS OF STORAGE EXPERIMENTS.

The foregoing conclusions are based on the results obtained from two series of experiments, as follows:

In October, 1903, a box of wild rice seed was received from Ontario, Canada. This seed, as soon as gathered, was loosely packed in moist sphagnum and sent by express to the Seed Laboratory of the United States Department of Agriculture. After a few days, while it was yet moist and before any fermentation had taken place, the seed was divided into four lots for special treatment, as follows:

(1) Seed submerged in water and placed in cold storage at a temperature of 32° to 34° F.

(2) Seed submerged in water and placed in cold storage at a temperature of 12° F. The seed was soon embedded in a solid mass of ice and remained so until samples were taken for test.

(3) Seed, without the addition of water, put into cloth bags and kept in cold storage at a temperature of 32° to 34° F.

(4) Seed, without the addition of water, put into cloth bags and kept in cold storage at a temperature of 12° F.

In October, 1904, a second consignment of seed was received from Minnesota, and the following additional storage experiments were made by Mr. C. S. Scofield, of the Bureau of Plant Industry.

(5) Seed submerged in water and placed in cold storage at a temperature of 32° to 34° F., as in No. 1.

(6) Seed submerged in water and placed in cold storage at a temperature of 12° F., as in No. 2.

(7) Seed submerged in water in a galvanized-iron bucket and stored on the roof of the laboratory building. The water was changed daily when not frozen.

(8) Seed submerged in water in a galvanized-iron bucket and stored on the roof of the laboratory building, as in No. 7. In this case the water was not changed save to replace the loss due to evaporation.

(9) The conditions for No. 9 were the same as those for No. 8, except that air was forced into the water daily when not frozen solid.

Samples of seed were taken from the different lots and tested for vitality at irregular intervals throughout the time of storage, which, in the former series, extended over a period of approximately thirteen months and in the latter series over a period of little more than six months.

Experiments Nos. 1 and 5.—The seed which was submerged in water and stored in the "chill room" showed no deterioration in vitality. The results of the final tests gave a germination varying from 79.8 to 88 per cent. This is practically Nature's method of preserving the vitality of the seed during the winter.

Experiments Nos. 2 and 6.—The seed which was submerged in water and stored at a temperature of 12° F. was all killed before the spring following the date of storage. Soon after being placed in storage the water was frozen solid and the seeds were embedded in a mass of ice, in which condition they remained throughout the experiment, a portion being cut out from time to time for germination tests. The complete loss of vitality in these two lots of seed is attributed not to the freezing directly, but to the thorough desiccation as a result of the continuous low temperature.

Experiments Nos. 3 and 4.—The samples of seed which were stored in cloth bags at the temperatures of 32° to 34° F. and of 12° F. had, for all economic purposes, entirely lost their vitality. The average percentage of germination, as shown by the 37 tests made from each of the two lots, was less than five-tenths of 1 per cent.

Experiment No. 7.—The seed which was submerged in water and stored on the roof of the laboratory building, the water being changed daily, showed a good percentage of germination when the last vitality tests were made. If only a small quantity of seed is desired for the spring planting and cold storage can not be readily secured, good results may be obtained by this treatment; but it is much less certain and probably more expensive than keeping the seed in cold storage, and for this reason is not recommended. The success of this method will likewise depend largely on the temperature of the water.

Experiments Nos. 8 and 9.—On April 22, 1905, samples taken from each of these two lots of seed showed a marked deterioration in vitality. Thoroughly mixed samples from No. 8 showed a vitality of only 58 per cent, while No. 9 had deteriorated to 14.3 per cent.

PACKING FOR TRANSPORTATION.

Too much care can not be given to the matter of packing the seed for transportation, for unless the packing is properly done the vitality of the seed will be destroyed during transit. What is here said applies to fresh seed which is to be sown in the autumn, as well as to seed which has been kept in cold storage during the winter. It must not be forgotten, however, that the vitality of cold-storage seed is more quickly destroyed on drying than that of fresh seed.

For transportation the seed should be carefully packed, with moist sphagnum, cocoanut fiber, or fine excelsior, in a loosely slatted box. If the time of transportation does not exceed five or six days no special precautions need be taken as to the temperature. During the period of transportation it is quite probable that some of the seed will germinate, but if sown at once growth will not be retarded and the roots will soon penetrate the soil and anchor the young plants.

If the time of transportation is necessarily long, it is recommended, if the best results are desired, that some provision be made for a reduced temperature. The nearer the temperature approaches that of freezing the better. It has been demonstrated, however, that a fair percentage of seed will remain germinable for a considerable time if packed as above described.

On October 10, 1904, Mr. C. S. Scofield sent a small quantity of wild rice, packed in moist sphagnum moss in a well-ventilated box, to Doctor De Vries, of Amsterdam, Holland. On October 14 or 15 this box was placed in cold storage on the steamer in New York Harbor. The box of seed was received by Doctor De Vries in good condition on November 2, twenty-one days after the seed was packed for shipment.

METHODS OF MAKING GERMINATION TESTS.

The samples were tested (1) between folds of blotting paper—our regular method for testing the germination of most seeds—and (2) in water, Nature's method of sowing wild rice seed. The latter method gave much better results and was the one finally adopted for the laboratory tests. The seed should be covered with water, the water in the dishes to be changed daily.

Plate I shows the importance of making the germination tests in water, as described in the foregoing paragraph. The seed was covered with water and placed in a germinating chamber maintained at an alternating temperature of 20° C. (68° F.) for eighteen hours, and 30° C. (84° F.) for six hours, until the majority of the seeds had germinated. At this stage the dish containing the seeds was transferred to the worktable, which was exposed to the temperature of the laboratory—approximately that of a living-room. The water in the

dish was changed daily during the period of germination, and water was afterwards added at irregular intervals to replace the loss by evaporation.

Plate II shows somewhat in detail the different stages in the germination of wild rice seeds. The seeds and seedlings are shown in natural size. In *b* and *c* the first sheath has just burst through the seed coats, taking a position at right angles to the seed proper. The lateral roots begin to emerge when the first sheath leaf has attained a length of ½ to 1½ inches. From this time growth continues rapidly, and by the time the seedlings are 2 or 3 inches long the root system is very well developed (*f* and *g*). At this stage under favorable conditions the plants have a good hold in the soil and will not be washed away by an ordinary freshet. The relative position of the actively growing seedling is always at right angles to that of the old seed, as shown in *f* and *g*.

EFFECT OF TEMPERATURE ON GERMINATION.

Germination tests were made at constant and alternating temperatures, ranging from 15° to 35° C. (59° to 95° F.). While no effort was made to show the minimum and maximum temperatures of germination, the percentage was somewhat reduced at a constant temperature of 35° C., and the maximum is not much above that. All of the other temperatures gave good results. The lower temperatures, however, were slightly more favorable than the higher. These facts are valuable to show that the wild rice plant can thrive in either warm or cold water, but better, perhaps, in northern than in southern latitudes.

SUMMARY.

(1) Under no circumstances should wild rice seed which is intended for planting be allowed to dry. Dried seed will germinate but rarely and should never be sown.

(2) Wild rice seed can be stored without deterioration if it is gathered as soon as matured, put into barrels or tanks, covered with fresh water, and, before fermentation has set in, stored at a temperature of 32–34° F. Seed treated in this way germinated as high as 88 per cent after being in storage 393 days. Fresh seed seldom germinates better, and usually not so well.

(3) After the seed is taken from cold storage it should not be allowed to dry. The vitality of cold-storage seed is destroyed on drying even more quickly than that of fresh seed.

(4) For transportation the seed should be packed in moist sphagnum, cocoanut fiber, or fine excelsior. If not more than five or six days are required for transit, no special precautions need be taken for controlling the temperature; but if the time for transportation exceeds

six days, provision should be made for a temperature sufficiently low to prevent marked fermentation. A temperature approximately freezing will give the most satisfactory results.

(5) Wild rice can be sown either in the autumn or in the spring. Spring sowing is preferable, thus avoiding the danger of having the seed eaten or destroyed by wild ducks or other animals during the fall or winter, or of its being buried or washed away by the heavy floods of late winter or early spring.

(6) Wild rice should be sown in the spring in from 1 to 3 feet of water which is neither too stagnant nor too swiftly moving, as soon as the danger of heavy floods is passed.

(7) Wild rice is of the greatest importance as a food for wild waterfowl, likewise a delicious breakfast food for man, and the area in which it is extensively grown should be extended. It will grow luxuriantly in either warm or cold water; furthermore, it can be grown successfully in water which is slightly salty to the taste.

(8) In determining the vitality of any sample of wild rice seed the germination tests should be made in water—the condition under which the self-sown seed germinates.

(9) The seed will germinate well at temperatures ranging from 15° to 30° C. The maximum temperature of germination is above 35° C. (95° F.), but better results are obtained at lower temperatures.

DESCRIPTION OF PLATES I AND II.

PLATE I. Wild rice growing in water. This seed was submerged at a temperature of 32–34° F. for approximately thirteen months. In making the germination test the seed was covered with water and placed in a germinating chamber maintained at a temperature of 20° C. (68° F.) for eighteen hours, and at 30° C. (86° F.) for six hours. After the majority of the seeds had germinated the dish was transferred to the worktable of the Seed Laboratory.

PLATE II. Progressive stages in the development of wild rice seedlings; *f* and *g*, seedlings showing the relative position of the growing seedlings and the parent seed, which take a position at right angles to each other when grown normally in water. (Natural size.)

WILD RICE GROWING IN WATER AFTER BEING KEPT WET IN COLD STORAGE AT A TEMPERATURE OF 32-34° F., FROM OCTOBER 19, 1903, TO NOVEMBER 15, 1904.

STAGES OF GERMINATION OF WILD RICE, SHOWING THE DEVELOPMENT OF THE ROOT SYSTEM AND THE RELATIVE POSITION OF THE SEEDLING AND THE PARENT SEED. NATURAL SIZE.

II.—THE CROWN-GALL AND HAIRY-ROOT DISEASES OF THE APPLE TREE.

By George G. Hedgcock, *Assistant in Pathology, Vegetable Pathological and Physiological Investigations.*

INTRODUCTION.

The diseases of the apple which have been classed under the name crown-gall have, during the last few years, attracted much attention, due partly to an increase of these diseases and partly to the enacting of more stringent State laws governing the shipment and inspection of trees.

A series of investigations into the nature of crown-gall upon the apple, pear, raspberry, peach, almond, grape, rose, and other plants has been in progress for some time in the Mississippi Valley Laboratory of the Bureau of Plant Industry at St. Louis, Mo., and also at other points in the Mississippi Valley. It is not to be assumed, however, that such diseases are more common in this locality than in some other portions of the United States. Apple crown-gall and hairy-root have been found in all nurseries that have been examined in various portions of the country.

This preliminary report is sent out, not with the intention of giving the results of all our investigations, but for the purpose of calling the attention of apple-tree growers to the different diseases hitherto known as apple crown-gall, and to endeavor to interest them in the collection of data regarding the predisposition of varieties to these diseases.

TWO DISTINCT DISEASES, CROWN-GALL AND HAIRY-ROOT.

Our investigations have resulted first in separating apple crown-gall into two diseases, which are considered distinct. The disease now designated as crown-gall is a callous-like gall growth of hypertrophied tissue following wounds on some portion of the root system of the tree, which rarely occurs above the ground on parts of the trunk or limbs. (See Pl. III, figs. 1 and 2.)

The malady now called the hairy-root disease is evidently the same as the one first given this name by Stewart, Rolfs, and Hall in Bulletin 191 of the New York State Experiment Station. It is characterized both in seedlings (Pl. IV, fig. 1, and Pl. V, fig. 2) and in grafted or

budded trees (Pl. III, figs. 3 and 4) by a stunted root system, accompanied with an excessive production of small fibrous roots, often originating in clusters from the main root, or taproot. Galls often occur in connection with hairy-root, but these are a result of wounds rather than a form of this disease. Seedlings of the hairy-root type, unless wounded, remain free from galls.

TYPES OF APPLE CROWN-GALL.

Apple crown-gall is of two types. A hard callous form is common on grafted trees at the union of the root and scion, and at any other point of the root system where wounds occur in either the cultivation or transplanting of trees (Pl. III, fig. 1). The results of extensive inoculations with this type have failed to prove that this disease is of a contagious nature.

A second type is a soft form more common on seedlings (Pl. IV, fig. 2), occurring more rarely on grafted trees (Pl. III, fig. 2). These softer galls resemble those of the raspberry and peach, in that they are soft and often rot off. It is not certain, however, that they, like the latter, are replaced the following year by a new gall growth from the adjacent live tissues of the host, nor is there proof yet that they are of a contagious nature.

EFFECT UPON THE LENGTH OF LIFE OF THE APPLE TREE.

Careful data are being collected from orchards and nurseries as to the effect of these diseases upon the life and fruitfulness of trees. Any information as to the locality of orchards in which diseased trees have been planted will be highly appreciated. In our crown-gall orchard there are more than 200 trees diseased with the hard type of crown-gall, and 200 healthy trees of the same grade planted under similar conditions. After two years' growth six of the crown-gall trees and nine of the healthy ones have died. No difference in the growth of the trees is noticeable. However, it can not be assumed from the results so far that, on the one hand, the disease may not yet shorten the life of the trees, or, on the other, that the trees may not entirely overcome its effects. A tree having crown-gall on its roots, however, can never be correctly graded with a smooth-rooted tree. The root system of a healthy fibrous-rooted apple tree is shown in Plate V, figure 1.

SUGGESTIONS TO NURSERYMEN.

Nurserymen are advised to be careful in the selection of seedlings for grafting and budding. All rough, warty, or galled seedlings should be thrown out, for most of them will form rough-rooted trees. Seedlings with tufted or hairy roots should also be rejected, for these,

FIG. 1.—APPLE CROWN-GALL ON GRAFTED TREE.

FIG. 2.—APPLE CROWN-GALL ON TRANSPLANTED SEEDLING.

FIG. 3.—HAIRY-ROOT DISEASE ON GRAFTED APPLE TREE.

FIG. 4.—HAIRY-ROOT DISEASE ON GRAFTED APPLE TREE.

Bul. 90, Bureau of Plant Industry, U. S. Dept. of Agriculture.

FIG. 1.—APPLE SEEDLINGS DISEASED WITH HAIRY-ROOT.

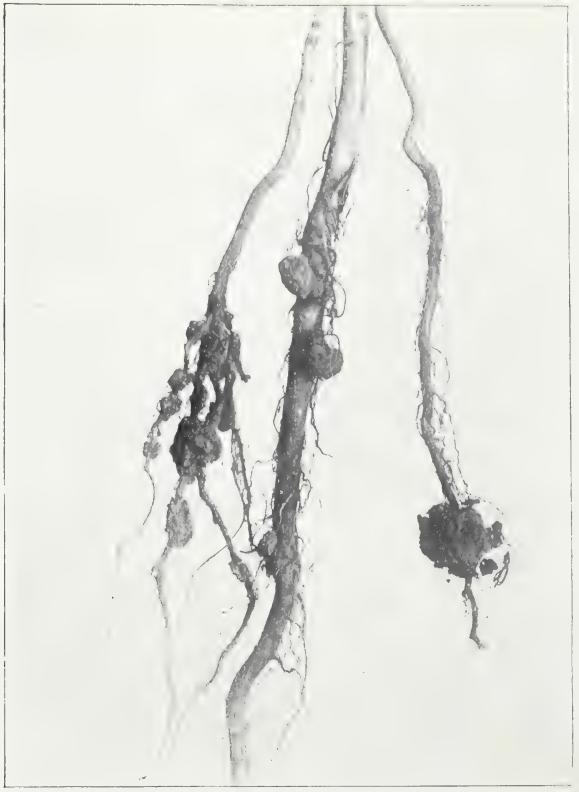

FIG. 2.—APPLE SEEDLINGS DISEASED WITH SOFT CROWN-GALL.

FIG. 1.—HEALTHY FIBROUS-ROOTED APPLE TREE, POT GROWN.

FIG. 2.—APPLE SEEDLINGS DISEASED WITH HAIRY-ROOT.

as shown by our experiments, develop into hairy-rooted trees with a very deficient root system. The hairy-root disease, as it appears from the results of two years' experiments, is not contagious. It is hoped in the near future to be able to offer some practical means of reducing the percentage of trees affected with these diseases in the nursery.

DATA DESIRED.

The hearty cooperation of nurserymen and orchardists in securing data is desired. It is hoped to secure the help of the leading nurserymen of this country in getting an accurate count from each nursery of the number of diseased trees in at least one row of every variety in all fields where the trees are all dug in one season. Such data are desired from every locality where apple trees are grown. Printed blanks with directions for tabulating such data have been provided and these will be sent to all who request them. Address the Mississippi Valley Laboratory, St. Louis, Mo.

B. P. I.—189.

III.—PEPPERMINT.[a]

By Alice Henkel, *Assistant, Drug-Plant Investigations.*

DESCRIPTION.

One of the most important essential oils produced in the United States is distilled from the peppermint plant and its varieties. The three kinds of mint grown in this country for the distillation of peppermint oil are the so-called American mint (*Mentha piperita* L.), the black mint (*Mentha piperita vulgaris* Sole), and the white mint (*Mentha piperita officinalis* Sole), the two last named being varieties of the American mint.

The American mint, although introduced from England many years ago, is so called from the fact that it has long been cultivated in this country, and the name "State mint" has been applied to it in the State of New York for the same reason.

The peppermint, or American mint, is now naturalized in many parts of the eastern United States, occurring in wet soil from the New England States to Minnesota, south to Florida and Tennessee. It is an aromatic perennial belonging to the mint family (Menthaceae), and propagates by means of its long, running roots (fig. 1). The smooth, square stems are erect and branching, from 1 to 3 feet in height, bearing dark-green, lance-shaped leaves, which are from 1 to 2 inches long, and from one-half to 1 inch wide. The leaves are pointed at the apex, rounded or narrowed at the base, sharply toothed, smooth on both sides, or with hairy veins on the lower surface. The flowers are borne in whorls in dense, terminal spikes; they are purplish, with a tubular, five-toothed calyx, and a four-lobed corolla. (Fig. 2.)

[a] In response to a steady demand for information relating to the peppermint industry, Miss Alice Henkel, Assistant in Drug-Plant Investigations, has been requested to bring together the most important facts regarding the history, culture, and utilization of the peppermint plant. The information here presented has been obtained in large part from scattered articles on the subject, and in part from experience with the plant in the Testing Gardens of the Department of Agriculture.

Rodney H. True, *Physiologist in Charge.*

Office of Drug-Plant Investigations,
Washington, D. C., October 14, 1905.

The two varieties mentioned are closely related botanically, although in general appearance they are quite different. The variety known as black mint (*Mentha piperita vulgaris*) has purple stems and slightly toothed, dark-green leaves, while the white mint (*Mentha piperita officinalis*) has green stems, with brighter green leaves, which are more lance-shaped and more deeply toothed. Black mint is much more hardy and productive than either the American mint or the white mint, and is grown on nearly all peppermint farms in this country. The white mint, which produces a fine grade of oil, is rarely cultivated on a commercial scale in this country on account of its inability to withstand the climate and its smaller yield of essential oil.

FIG. 1.—Peppermint "runners," showing method of propagation.

The oils spoken of as Japanese and Chinese "peppermint" oils are not obtained from the true peppermint plant, but are distilled from entirely different species, namely, *Mentha arvensis piperascens* Malinvaud and *Mentha arvensis glabrata* Holmes, respectively.

FIG. 2.—Leaves and flowering top of peppermint.

COUNTRIES WHERE GROWN.

The most important peppermint-producing countries are the United States, England, and Japan. Peppermint is grown on a smaller scale in Germany, France, Italy, Russia, China, and southern India.

In Japan, peppermint cultivation is said to have been undertaken before the Christian era. The plant grown there is not, as already stated, the peppermint cultivated in our country, but *Mentha arvensis piperascens*, which is entirely dis-

tinct from the true peppermint, not only botanically but also in taste and odor.

Peppermint is cultivated on many drug farms in England, especially at Mitcham, the middle of the eighteenth century marking the beginning of peppermint cultivation in that country. Up to 1805, however, there were no stills at Mitcham, and the crops obtained there were sent to London for distillation. About 1850, at which time the peppermint industry in England was at its height, the effect of American competition began to be felt, and caused a decided check in the production.

PEPPERMINT CULTIVATION IN THE UNITED STATES.

Wayne County, N. Y., in 1816, was the first locality in this country to distill peppermint on a commercial scale. The supply of root-stocks was obtained from the wild plants found growing along the banks of streams and brooks. Adjacent counties soon undertook the cultivation of peppermint, but Wayne County was then, and is now, the principal peppermint district in New York.

The cultivation of peppermint was extended to Ashtabula, Geauga, and Cuyahoga counties in Ohio, and also to northern Indiana. Roots were taken from Ohio into St. Joseph County, Mich., the first plantation being made on Pigeon prairie in 1835. Other plantations in St. Joseph County were established the following years, and adjoining counties soon took up the cultivation of peppermint, and southwestern Michigan has been for thirty-five years or more the greatest peppermint-producing section in the United States.

About 1844 an interesting peppermint-oil monopoly[a] was undertaken by a New York firm, which seems to have put an end to peppermint cultivation in Ohio, for none of the counties just mentioned has since been heard from as a peppermint-producing section.

The first step taken by this New York firm in its efforts to control the peppermint-oil market was to send a representative to Liverpool, England, to ascertain the amount annually demanded by that market, which was found to be about 12,000 pounds. This done, another agent was sent West to determine the amount produced annually, with the result that it was found that the farms in New York did not produce enough oil for their purposes, the plantations in Ohio too much, while those in Michigan seemed to produce just about the right amount to satisfy the Liverpool demand. A contract was then entered into by this agent with the producers in New York and Ohio "whereby he bound them under heavy penalties to plow up their mint fields and destroy the roots, and not plant any more mint, or sell or give away any roots, or produce or sell any mint oil for the

[a] Proc. Amer. Pharm. Assoc., 7: 449–459 (1858).

period of five years." For this wholesale destruction of their mint fields the producers received a bonus of $1.50 per acre. Next a contract was made by the agent with the producers of St. Joseph County, Mich., agreeing to pay them $2.50 a pound for their mint oil, every ounce of the mint oil to be delivered for a period of five years to the agents named in the contract. They also were prohibited during this period from extending their plantations and from selling roots to anyone. The producers held to these contracts for about three years, after which period the New York firm was not so anxious to enforce them, having, in the meantime, acquired a large fortune through its peppermint-oil monopoly.

Since that period the area devoted to peppermint cultivation in Michigan has steadily increased, and northern Indiana, with its principal centers of production in St. Joseph, Steuben, and La Grange counties, continues to place on the market a considerable quantity of oil. Ohio seems to have abandoned peppermint cultivation, at least on a commercial scale, and New York, for a number of years and until very recently, had greatly reduced the area under peppermint, thousands of acres formerly devoted to this crop having been given over to sugar beets, onions, and celery. In 1889 Wayne County, N. Y., had 3,325 acres of peppermint, whereas in 1899 there were only 300 acres. In 1905, about 933 acres were under cultivation.

Special canvassers appointed by the State of Michigan[a] made a canvass of 299 growers in the peppermint district in that State, covering 39 townships in nine counties (Allegan, Berrien, Branch, Cass, Kalamazoo, Oakland, St. Joseph, St. Clair, and Van Buren), and the total number of acres under peppermint cultivation, the number of pounds of oil distilled, and the average number of pounds per acre, as ascertained by this canvass, for the years 1900, 1901, and 1902, are as follows:

Items.	1900.	1901.	1902.
Total number of acres grown	2,112	2,782½	6,400⅝
Total number of pounds distilled	47,628½	63,718⅝	82,420¼
Average number of pounds per acre	22.5	23.9	12.8

CULTIVATION.

Peppermint cultivation is most profitable on muck lands, such as are now used in Michigan for this crop and for celery and cranberry culture. These muck lands were formerly marshes and swamps, which have been reclaimed by draining, plowing, and cultivating, the swamp vegetation having been thus subdued, and the decayed

[a] Twentieth Annual Report of the Bureau of Labor of the State of Michigan, 1903, pp. 438–447.

vegetable matter resulting in a very black soil which is most admirably adapted to mint cultivation. Formerly peppermint was grown exclusively on upland soil in Michigan, but it is a very exhausting crop on such land. Only two crops can be obtained from upland plantations, and after the second year's harvest the land is plowed and a rotation of clover, corn, etc., is practiced for five years before peppermint is again planted. But on the rich muck land peppermint can be grown year after year for six or seven years, the land being plowed up after each crop is harvested, and the runners turned under to form a new growth the succeeding year. The ground is harrowed in autumn and again in spring, and carefully weeded. Peppermint will grow, however, on any land that will produce good crops of corn, the ground being prepared by deep plowing and harrowing.

In Michigan[a] the land is plowed in the autumn, and early in spring it is harrowed and marked with furrows about 3 feet apart. The roots selected for planting are from one-eighth to one-quarter of an inch thick, and from 1 to 3 feet long; and the workmen engaged in "setting mint," as the process is called, carry these roots in sacks across their shoulders and place them in the furrows by hand, covering the roots with one foot and stepping on them with the other. The roots are planted so close together in the furrow as to form a continuous line. An expert workman can plant about an acre in a day.

In about two weeks the young plants will make their appearance, and are carefully hoed and cultivated until July and August, when the plants have usually sent out so many runners as to make further cultivation difficult. The crop is cultivated with horse cultivators, but if the land was very weedy in the first place, the weeds will have to be pulled by hand. It is very necessary that the land be free from weeds, as any collected with the peppermint crop will seriously injure the quality of the oil.

It may be interesting to note here that on muck lands, when necessary, the horses are usually provided with mud shoes to prevent their sinking into the soft, wet ground, these mud shoes consisting of wide pieces of iron or wood about 9 by 10 inches, fastened to the hoofs and ordinary shoes by means of bolts and straps.

CONDITIONS INJURIOUS TO CROP.

Cold and wet weather or extremely dry periods have a very unfavorable effect on the mint crop. Insect enemies also tend to cut down the mint harvest—grasshoppers, crickets, and cutworms sometimes doing considerable damage. A rust, causing the foliage to drop off

[a] Twentieth Annual Report of the Bureau of Labor of the State of Michigan, 1903, pp. 438–447.

and leaving the stems almost bare, is apt to follow if very moist weather occurs toward the latter part of the season. Weeds are especially to be avoided in a mint field, since, as stated, the quality of the oil will be seriously impaired if these are harvested with the peppermint. The weeds generally found in a peppermint field are Canada fleabane (*Leptilon canadense*), fireweed (*Erechtites hieracifolia*), giant ragweed (*Ambrosia trifida*), pennyroyal (*Hedeoma pulegioides*), Eaton's grass (*Eatonia pennsylvanica*), June grass (*Poa pratensis*), and other low grasses.

HARVESTING AND DISTILLATION.

The first crop of mint is harvested in the latter part of August, when the plants are in full flower, and the gathering continues until about the middle of September, the stills running night and day until all the mint is disposed of. The first crop is usually cut with a scythe, as mowing machines do not work well on soft cultivated land. The succeeding crops are cut with a mowing machine or sweep-rake reaper. The highest yield per acre and the best quality of oil are obtained from the first year's crop. Sometimes, if the weather conditions have been very favorable, a second cutting is made. The yield of oil from peppermint obtained from the same field sometimes varies very much, the condition of the atmosphere seeming to exert an influence upon it, as it is said that mint cut after a warm and humid night will yield more oil than that cut after a cool and dry night. It requires about 330 pounds of dried peppermint to produce 1 pound of oil, and the yield of oil from an acre ranges from 12 to 50 pounds.

If the mint crop has been grown on muck land, all that is necessary after the crop has been harvested is to plow up the land and turn the runners under for a new crop. If grown on upland, after the second year's crop is in, or, at the most, after the third year's harvest, the land is plowed and then given up to other crops. Peppermint exhausts the land, and it is necessary to practice rotation of crops for about five years in order to put the land in condition if it is desired to use it again for peppermint cultivation.

After the plants are cut they are usually placed in windrows until they are dried, but are not allowed to become so dry as to permit the leaves to shatter off, and are then taken to the distillery. Some growers believe that if the plants are allowed to dry there will be a smaller oil content owing to the escape of some of the oil into the atmosphere, and so have the plants brought to the distillery in the green state; but Mr. A. M. Todd[a] is of the opinion that no loss of oil will result

[a] Amer. Jour. Pharm., 60: 328–332 (1888).

from drying, his experiments along this line showing that the dry plants can be distilled three times as rapidly as the green plants, and that a larger quantity of oil may be obtained. He states that—

> To obtain the best results, both as to quality of essential oil and economy of transportation and distillation, the plants should be dried as thoroughly as possible without endangering the loss of the leaves in handling. Distillation should then take place as soon as convenient to prevent the oxidation of the oil in the leaf by atmospheric action.

The smaller producers, who have no stills of their own, have their mint crop hauled to the nearest peppermint distillery, where it is distilled for them at a cost of 25 cents per pound of oil.

DESCRIPTION OF STILL.

The apparatus used in peppermint distillation in the early years of the industry in this country consisted of a copper kettle, from the top of which a pipe connected with a condensing "worm." Water was placed in the kettle and the plants were immersed in it, and direct heat was applied to the bottom from a furnace. With such a still only about 15 pounds of oil could be obtained from a charge. In 1846, large wooden vats were substituted for the copper kettles, and the plants were distilled by steam passing through them. The kettle formerly used as the still was now employed to generate steam, a long pipe conveying the steam to the bottom of the vats. With this method of distillation from 75 to 100 pounds of oil could be obtained from a charge without much additional expense.

A modern peppermint still (fig. 3) may be briefly described as follows: The apparatus required consists of a boiler, a pair of large circular wooden vats, a condenser, and a receiver. The boiler, of course, is used for the generation of steam.

Two wooden vats are used in order that they may be filled and emptied alternately. These vats are about 6 feet high and about 5 feet in diameter, with tight-fitting removable covers and perforated false bottoms. Steam pipes are led from the boiler into the bottom of the vats.

The condenser consists of a series of pipes of block tin, either immersed in tanks of cold water or over which cold water is kept running, the condenser being connected with the top of the distilling vats. The condensed steam, together with the oil, flows into a metallic receiver, in which the oil, being lighter than the water, rises to the top and can be drawn off.

The perforated false bottoms with which the vats are supplied permit the passage of steam. A strong iron hoop is placed about this false bottom, and two pairs of stout chains, which meet at the top

of the vat in a pair of rings, are attached to it. After the charge has been distilled it is drawn from the vats by means of this arrangement.

The plants are thrown into the vats and are closely packed by two or three men tramping upon them, and as the vat becomes about one-third full the packing is still further assisted by turning in a small supply of steam, which softens the plants. When the vat is filled the tight cover is replaced and a full head of steam turned on. In the largest distilleries the vats have a capacity of from 2,000 to 3,000 pounds of dried plants each.

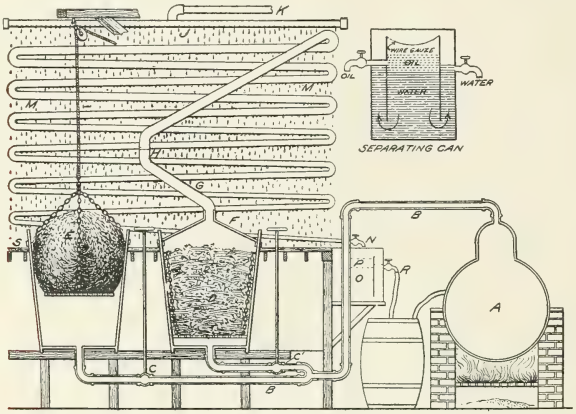

FIG. 3.—Peppermint still. (After Dewey, in Bailey's Cyclopedia of American Horticulture.)

A, boiler; *B*, steam pipes leading to vats; *C*, valves for shutting off steam; *D*, mint packed in vat ready for distilling; *E*, mint being lowered into vat; *F*, tight-fitting cover used alternately for both vats; *G*, pipe from top of vat, joined at *H* so as to swing to other vat; *J*, perforated pipe, from which cold water drops over condensing tubes; *K*, supply pipe for cold water; *M*, condensing pipes; *N*, outlet for condensed oil and water; *O* and *P*, water and oil in separating can; *R*, outlet for water; *S*, floor of distilling room.

Large tanks are used for storing the oil, and cans holding 20 pounds each are employed for shipping, three of these cans being placed in a wooden case.

The peppermint hay which remains after distillation is used as a fertilizer or is fed to stock.

PEPPERMINT OIL AND MENTHOL.

Peppermint leaves and flowering tops are official in the Eighth Decennial Revision of the United States Pharmacopœia, as are likewise the following products and preparations derived from these parts: Oil of peppermint, menthol, spirit of peppermint, and peppermint water.

The United States Pharmacopœia describes oil of peppermint as "a colorless liquid, having the characteristic strong odor of peppermint and a strongly aromatic pungent taste, followed by a sensation of cold when air is drawn into the mouth." It is largely used in medicine, internally as a stimulant and carminative, and externally to relieve neuralgic and rheumatic conditions. It is also used for flavoring and scenting confectionery, cordials, and cosmetics. There is a slight difference in the odor of white and black peppermint oil, the black being more pungent and less agreeable in fragrance than the white, which has a much finer odor, but, as already indicated, the white mint is less hardy than the black and yields a smaller quantity of oil.

The Japanese oil of peppermint, which, as pointed out elsewhere in these pages, is obtained from a different species of mint than that which produces the true oil of peppermint, is very inferior to the last named. It has a very unpleasant odor and a bitter, disagreeable taste, but it is a heavy oil and contains a higher percentage of menthol and, being a very much cheaper oil, it is liable to be used as an adulterant of true peppermint oil.

Menthol, formerly known as peppermint camphor, is the solid constituent of oil of peppermint, obtained by subjecting the distilled oil to an exceedingly low temperature by means of a freezing mixture. Its properties are about the same as those of oil of peppermint, only somewhat intensified. It is very largely made up into cones or pencils, which furnish a popular remedy, to be applied externally or inhaled, for the relief of headache, neuralgia, catarrh, asthma, and kindred affections. It is also largely employed in other forms of medication. The name "pipmenthol" has been applied to the menthol obtained from the American oil, to distinguish it from the Japanese menthol. Pipmenthol is said to have a distinct odor of peppermint, while the Japanese menthol has but a slight peppermint odor.

EXPORT OF PEPPERMINT OIL.

The exports of peppermint oil during the fiscal year ended June 30, 1904, amounted to 42,939 pounds, valued at $124,728. Germany and the United Kingdom were the largest consumers, the former receiving 22,372 pounds, valued at $65,505, and the latter 11,558 pounds, worth $31,798.

The following tables show the export of peppermint oil, by countries, for the fiscal year ended June 30, 1904, and the quantities and values of peppermint oil exported for a period of ten years, from July 1, 1894, to June 30, 1904, inclusive:

Exports of peppermint oil, by countries, for the fiscal year ended June 30, 1904.[a]

Country.	Quantity.	Value.
	Pounds.	
Belgium	473	$1,585
France	3,054	10,059
Germany	22,372	65,505
Italy	826	2,471
Netherlands	590	1,934
United Kingdom	11,558	31,798
Dominion of Canada:		
Nova Scotia, New Brunswick, etc	85	234
Quebec, Ontario, Manitoba, etc	1,165	3,306
Newfoundland and Labrador	94	204
West Indies:		
British	183	700
Cuba	29	87
Danish	17	55
Dutch	20	61
Argentina	1,237	3,504
British Guiana	10	31
Peru	50	175
British Australasia	1,176	3,019
Total	42,939	124,728

[a] The Foreign Commerce and Navigation of the United States for the year ending June 30, 1904, vol. 1, p. 531, Bureau of Statistics, Department of Commerce and Labor.

Quantities and values of peppermint oil exported during the fiscal years 1895 to 1904, inclusive.[a]

Fiscal year.	Quantity.	Value.	Fiscal year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1895	87,633	$194,616	1900	89,558	$90,298
1896	85,290	174,810	1901	60,166	63,672
1897	162,492	257,484	1902	36,301	54,898
1898	145,375	180,811	1903	13,033	34,943
1899	117,462	118,227	1904	42,939	124,728

[a] From The Foreign Commerce and Navigation of the United States for the year ending June 30, 1902, vol. 2, p. 309, Bureau of Statistics, Treasury Department; and The Foreign Commerce and Navigation of the United States for the year ending June 30, 1904, vol. 1, p. 192, Bureau of Statistics, Department of Commerce and Labor.

PRICES OF PEPPERMINT OIL.

The price of peppermint oil was very low for a few years prior to 1900, the enormous production of 1897 resulting in a great drop in price. The lowest price paid for it was in 1899, when it brought only 75 cents per pound. As a result of the low price a great many mint farmers restricted the area of their mint plantations or altogether abandoned peppermint cultivation. The smaller output of the following seasons again sent prices up, and in 1902 the oil sold as high as $4.75 a pound, which price was maintained until early in 1903, when it gradually declined, until toward the end of that year it reached $2.20 per pound.

The following table[a] gives the highest and lowest prices of peppermint oil in bulk from 1873 to September 16, 1905:

Year.	Highest.	Lowest.	Year.	Highest.	Lowest.	Year.	Highest.	Lowest.
1873	$3.15	$3.15	1884	$3.00	$2.50	1895	$2.00	$1.70
1874	5.25	3.75	1885	4.37	2.75	1896	1.85	1.20
1875	5.50	3.20	1886	3.60	2.75	1897	1.25	.90
1876	3.75	2.40	1887	2.75	1.90	1898	.90	.80
1877	3.00	1.75	1888	2.40	1.75	1899	.90	.75
1878	2.00	1.50	1889	2.30	1.80	1900	1.10	.80
1879	2.65	1.45	1890	2.40	1.80	1901	1.80	1.10
1880	2.87	2.60	1891	2.50	2.45	1902	4.75	1.70
1881	2.85	2.35	1892	2.50	2.15	1903	4.75	2.20
1882	2.50	2.25	1893	2.45	2.15	1904	3.75	2.65
1883	2.60	2.20	1894	2.45	1.70	1905*	3.45	2.25

* To September 16.

The good prices of the past few years have caused many farmers to look again to peppermint as a profitable crop, as noted in increased areas under cultivation in many localities. This is the case not only in Michigan and Indiana, but also in New York, where for many years the peppermint industry has been declining. Thus, if favorable conditions of growth prevail, an increased production may be looked for within the next few years, which will have the effect of again depressing prices.

As is the case with other products the prices of which are subject to great fluctuations, the condition of the market for peppermint oil needs to be closely observed. The cost of cultivation per acre has been stated at from $12 to $14, and, with a charge of 25 cents per pound of oil for distillation, the market price may easily fall below the cost of production.

[a] From Oil, Paint, and Drug Reporter, September 18, 1905, p. 7.

IV.—THE POISONOUS ACTION OF JOHNSON GRASS.[a]

By A. C. Crawford, *Pharmacologist, Poisonous-Plant Investigations.*

Johnson grass, which was introduced from Turkey into this country about 1830,[b] has spread so that in many places it is considered as a weed and pest.[c] Some farmers, however, have utilized the dried grass as hay with advantage, either alone or combined with other food material,[d] and chemical analyses have proved its value as feed. Recently reports have come to this office from California of the death of cattle under such circumstances as to point to Johnson grass as the causative agent—the cattle dying in thirty minutes after eating the grass. Johnson grass belongs to the same genus of the Gramineae as sorghum. This group has been partially investigated chemically, and it has been found that the fresh green plants of various members yield

[a] This office has from time to time received communications from stockmen, especially in the lower part of California, Arizona, and adjacent territory, expressing a suspicion that the eating of Johnson grass had caused the death of stock with rather sudden and violent symptoms. There has seemed to be little ground in poisonous-plant literature to support such an explanation. Last summer, however, convincing observations were reported from California by a stockman who had lost heavily, and a supply of the grass in question was obtained. The result of the study of this material was so positive, and the possibility of damage due to this unsuspected forage plant so clear, that this preliminary notice is put out in the hope of getting observations and material for study from many sources, in order, if possible, to determine the conditions under which the poisonous properties are developed and over how wide an area they are likely to appear.

Rodney H. True, *Physiologist.*

Office of Poisonous-Plant Investigations,
Washington, D. C., December 11, 1905.

[b] Ball, C. R. Johnson Grass. Bul. No. 11, Bureau of Plant Industry, United States Department of Agriculture, 1902.

[c] Spillman, W. J. Extermination of Johnson Grass. Bul. No. 72, Part III, Bureau of Plant Industry, United States Department of Agriculture, 1905.

[d] North Carolina Agricultural Experiment Station, Bul. 97, p. 92; Vasey, G., Grasses of the South, Bul. No. 3, Division of Botany, United States Department of Agriculture, 1887; Report of the Commissioner of Agriculture for 1881, pp. 231, 232, 239, 241; Report of the Secretary of Agriculture, 1890, p. 381.

hydrocyanic acid as a result of the action of enzymes on more highly complex bodies.[a]

Ball[b] in 1902 stated that at that time there had been no official reports to his office of cases of poisoning by Johnson grass, but that there were some newspaper statements to that effect. He thought these accounts were probably not authentic, but stated that "since Johnson grass is closely related to sorghum, which is known to be poisonous under some circumstances, it would not be surprising if Johnson grass should also be poisonous under like conditions. * * * In comparison with the great number of cattle fed or pastured in Johnson grass, the reported cases of poisoning are extremely rare."

The first report of the poisonous action of Johnson grass which reached the Department came from Miles City, Mont. Mr. William Story reported that he and a neighbor had lost several head of cattle after they had eaten small quantities of the grass, and that they had died very suddenly. Mr. Story suggested that there was "something peculiarly poisonous about the grass." The Commissioner of Agriculture in publishing this report stated that "although the grass has been cultivated in the South for forty or fifty years, no similar charges have been made against it."[c]

In India this plant is widely used as a fodder for cattle,[d] and the natives make use of the seeds for food. It has been noted there that deaths in cattle frequently occur when, on account of the failure of rain, the plants which have reached a certain size become stunted and withered. The toxic principle appears simultaneously over a wide area, but soon disappears if a rainfall occurs.[e] The deaths of cattle have been attributed by some to an insect living upon the plant, and in Australia it is the belief that *Sorghum vulgare*, which also yields hydrocyanic acid, becomes more poisonous when attacked by an insect during a drought. A similar observation has been made with *Sorghum vulgare* in the Sudan. Balfour[f] found that one specimen of the plant which harbored aphids yielded more hydrocyanic acid than a

[a] Dunstan, W. R., and Henry, T. A., The Nature and Origin of the Poison of Lotus Arabicus, Phil. Trans. Roy. Soc. London, 1901, vol. 194, B., p. 515; Dunstan, W. R., and Henry, T. A., Cyanogenesis in Plants, Phil. Trans. Roy. Soc. London, 1902, vol. 199, A., p. 399; Slade, Henry B., Prussic Acid in Sorghum, Jour. Amer. Chem. Soc., 1903, vol. 25, pp. 55–59; Slade, Henry B., Study of the Enzymes of Green Sorghum, Fifteenth Annual Report, Agricultural Experiment Station of Nebraska, 1902, pp. 55–62; Brünnich, J. C., Hydrocyanic Acid in Fodder-plants, Jour. Chem. Soc., 1903, vol. 83, part 2, pp. 788–796.

[b] Bul. No. 11, Bureau of Plant Industry, United States Department of Agriculture, p. 23.

[c] Report of the Commissioner of Agriculture, 1885, p. 74.

[d] Duthie, J. F. Fodder Grasses of Northern India, 1888, p. 41.

[e] Pease, H. T. Poisoning of Cattle by Andropogon Sorghum. Jour. Compar. Med. and Vet. Arch., vol. 18, 1897, p. 679. See also Agr. Ledger, 1896, No. 24.

[f] Balfour, Andrew. Cyanogenesis in Sorghum Vulgare. First Report, Wellcome Research Laboratory, at Gordon Mem. College, Khartum, 1904, p. 47.

second one without parasites. Pease has lately claimed that the deaths from Johnson grass in India were really cases of nitrate poisoning, as he found 25 per cent of nitrate of potassium in the stem of the plant and was able to produce somewhat similar symptoms in animals by feeding them this salt. Johnson grass is being introduced into Australia as a fodder plant, but as yet no reports of its poisonous action there have been noted by the writer.[a]

There has been some chemical study of Johnson grass, but not with reference to any poisonous principle.[b]

A fresh, green, mature, nonflowering specimen of Johnson grass, moistened with a little water and preserved with chloroform, was sent from Santa Rosa, Cal., in sealed glass vessels, to this laboratory. This was botanically identified here as Johnson grass. This specimen was not immediately worked up, but remained in the jars for about a month. At that time on opening the jars a marked odor of hydrocyanic acid, together with that of chloroform, was detected. The ground-up plant, with the water in which it came, was distilled, and the distillate was caught in sodium hydrate solution. This distillate, on mixing with ferrous sulphate and acidulation with hydrochloric acid, gave a heavy blue precipitate with ferric chlorid. Yellow ammonium sulphid was added to the same filtrate, and the mixture was evaporated to dryness on the bath. The dried residue was then taken in hydrochloric acid water, and on the addition of ferric chlorid the fluid gave the characteristic red reaction for hydrocyanic acid. The nitro-prussid, picric acid, and silver nitrate reactions were all positive for hydrocyanic acid. The aqueous fluid in which the plant was shipped was filtered off from the plant and gave on distillation all the above reactions for hydrocyanic acid.

According to our California correspondent, this plant is poisonous when grown on irrigated as well as on nonirrigated lands, but especially so when grown on irrigated soil and the growth has become rank.

Recently Dunstan[c] has shown that lima beans (*Phaseolus lunatus*), which when grown wild in Mauritius yield sufficient hydrocyanic acid to produce poisoning, when cultivated in Burma lose this toxicity almost entirely, although it may return most unexpectedly.[d] He was unable, however, to determine the condition which increased its poisonous properties.

It is interesting to note, besides this production of hydrocyanic acid from complex glucosids, that proteids, when subjected to oxidation

[a] Maiden, J. H. Useful Australian Plants. Department of Agriculture New South Wales, Misc. Pub. No. 22, 1896.

[b] Annual Report of the Commissioner of Agriculture, 1878, p. 168.

[c] Dunstan, W. R. Phaseolus Lunatus. Agricultural Ledger, 1905, No. 2.

[d] Church, A. H., Food-Grains of India, 1886, p. 155; Watt, George, Dictionary of the Economic Products of India, vol. 6, part 1, 1892, p. 187.

under certain conditions, also yield it.[a] In fact, hydrocyanic acid may exist in plants in two forms, either as the acid or as one of its salts, or in the form of complex glucosids.[b] Under the circumstances, the conclusions of Brünnich[c] should be held in mind, viz, that "all fodder plants related to sorghum must be used with discretion in either the green or the dried state, and should not be given in large amounts to animals which have fasted for some time."

In reference to other forage plants, Avery[d] says that "Kafir-corn leaves also contain this poison, but other forage plants—clover, alfalfa, grasses, and corn—give no test for prussic acid," and Brünnich also found it in Guinea grass or *Panicum maximum* and *P. muticum*. Many facts have been collected relative to the distribution of hydrocyanic acid in plants, yet its exact significance in their metabolism is unknown.[e] The question as to the relationship of parasites[f] to the production of hydrocyanic acid remains to be solved.

Later investigations will be carried on to determine the nature of this cyanogenetic compound, to determine whether hydrocyanic acid is present in all stages of its growth, but disappears on drying the plant, whether the hydrocyanic acid production occurs under all conditions or only when grown on certain soils, and the amount produced. Hydrocyanic acid will also be looked for in other members of this genus.

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[a] Plummer, R. H. A. The Formation of Prussic Acid by the Oxidation of Albumins. Jour. Physiol., vol. 31, 1904, p. 65; vol. 32, 1904, p. 50.

[b] Les Nouveaux Remèdes, vol. 14, 1898, p. 272.

[c] Jour. Chem. Soc., 1903, vol. 83, part 2, p. 792.

[d] Avery, S. Laboratory Notes on Poison in Sorghum. Jour. Compar. Med. and Vet. Arch., vol. 23, 1902, p. 705.

[e] Czapek, F. Biochemie d. Pflanzen, 1905, vol. 2, p. 259.

[f] Literature on some parasites of the sorghum family can be found in Bot. Gaz., vol. 28, 1899, p. 65. Also in Busse, W., Untersuch. u. d. Krank. der Sorghum Hirse, Arb. a. d. biol. Abtheil. f. Land u. Forstw. am kaiserl. Gesundheitsamt, 1904, vol. 4.

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